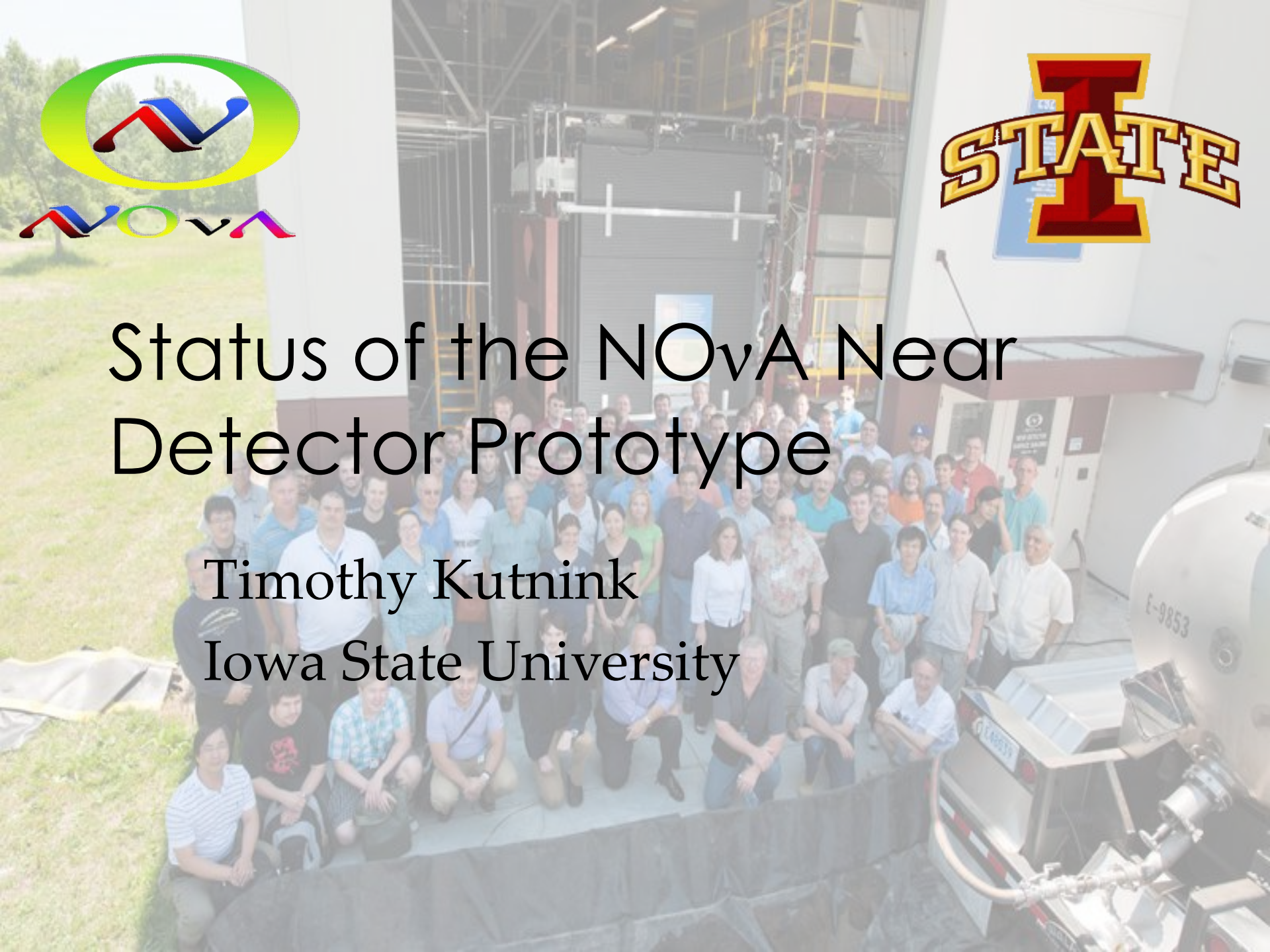
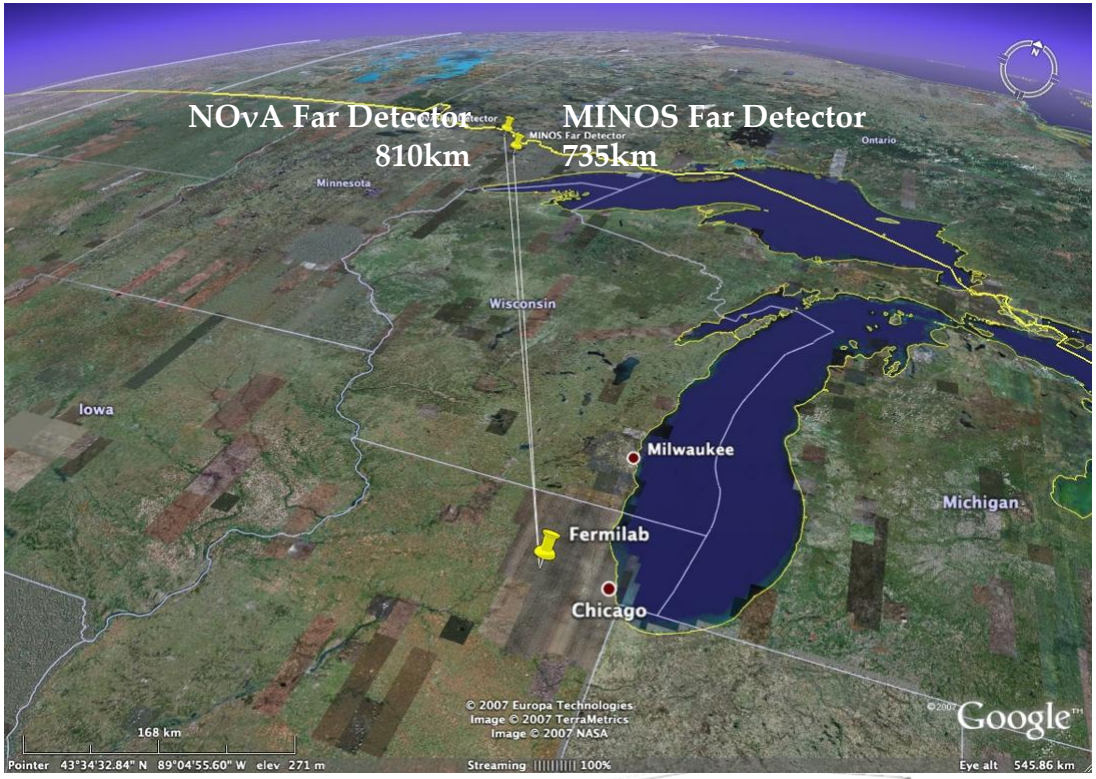


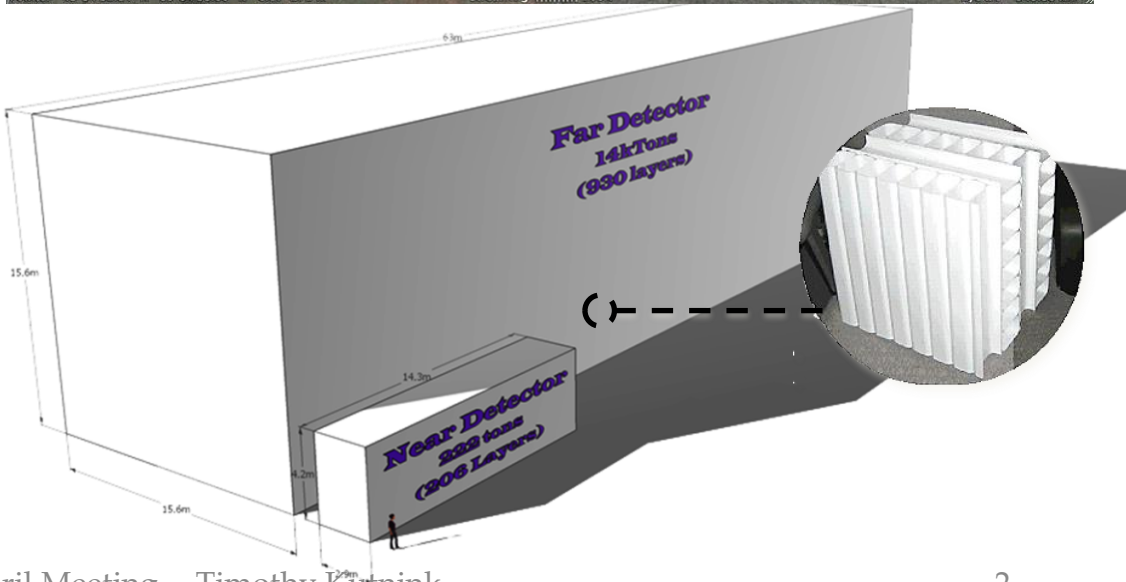
# Status of the NOvA Near Detector Prototype

Timothy Kutnink
Iowa State University

# NOνA

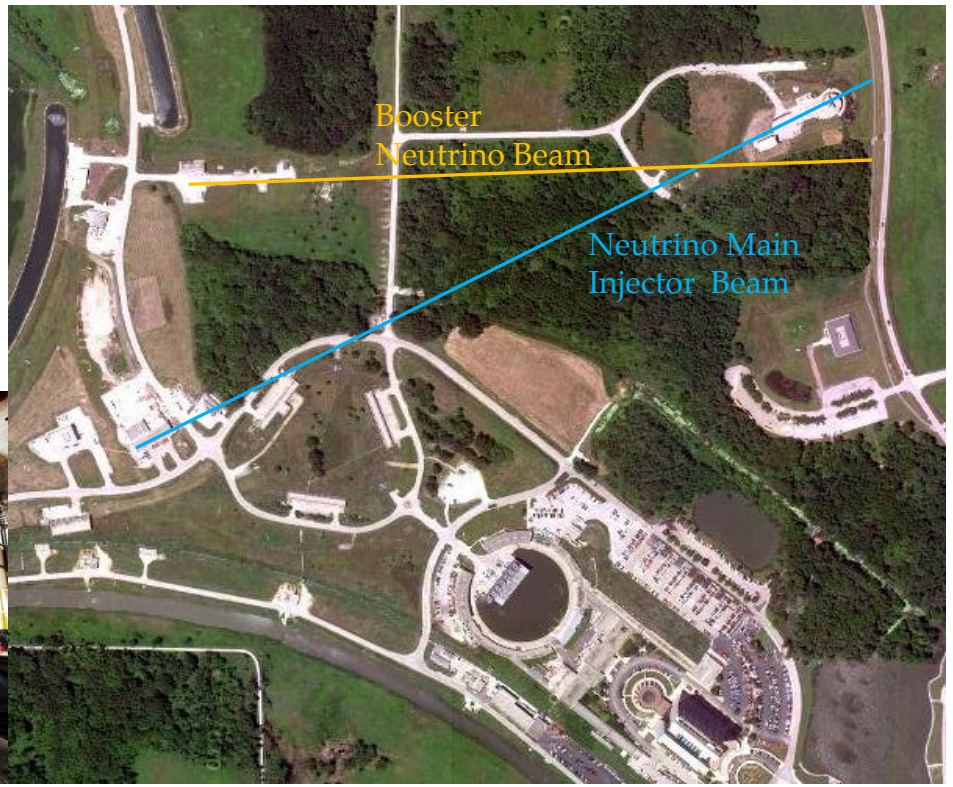
- NuMI Off-axis $\nu_e$ Appearance (NOνA)
- NOνA is a long-baseline experiment designed to:
  - Measure $\theta_{13}$ and $\delta_{CP}$
  - Determine the mass hierarchy.
  - Make precision measurements of $\theta_{23}$ and $\Delta m^2_{32}$
- NOνA's Near and Far detectors are 14 mrad off-axis of the NuMI beam:
  - PVC extruded into cells filled with liquid scintillator.
  - Light is collected by wavelength shifting fibers connected to photo sensor.
  - 360000 cells (Far) 16000 cells (Near).

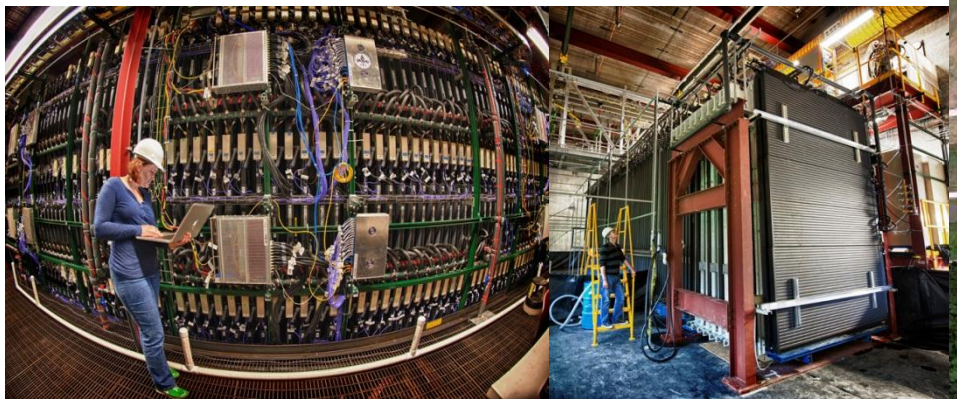


# NOvA Near Detector Prototype

- The NOvA Prototype detector (NDOS) located on the surface at Fermilab.
- Uses the same materials and technologies as the Near and Far detectors.
- The NDOS is ~6.1˚ off the NuMI beam axis and on the Booster beam axis.

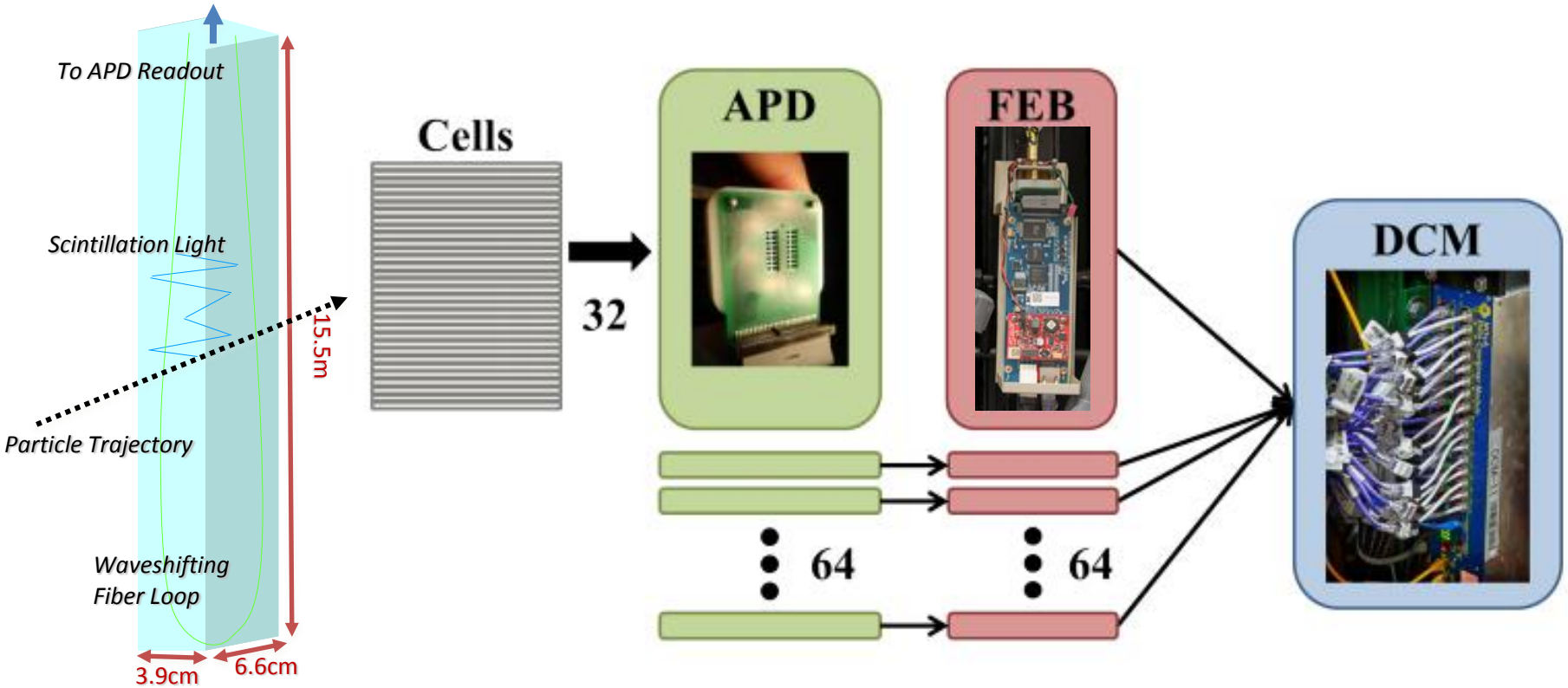


- Goals:
  - Testing assembly techniques for the Near and Far Detectors.
  - Installing, operating, testing the NOvA electronics and DAQ.
  - Developing reconstruction and calibration methods, and physics analyses.

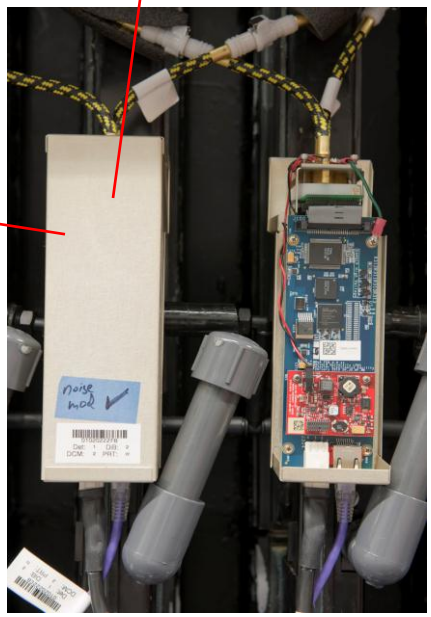
# The Detector Technology

- Light is generated by charged particles and collected by wavelength-shifting fiber.
- Each avalanche photodiode (APD) reads out 32 cells.
- Each APD is connected to a Front End Board (FEB).
- The FEB digitizes signal, sends it to a Data Concentrator Module (DCM).
- Each DCM can read 64 FEBs. The NDOS uses 11 DCMs.

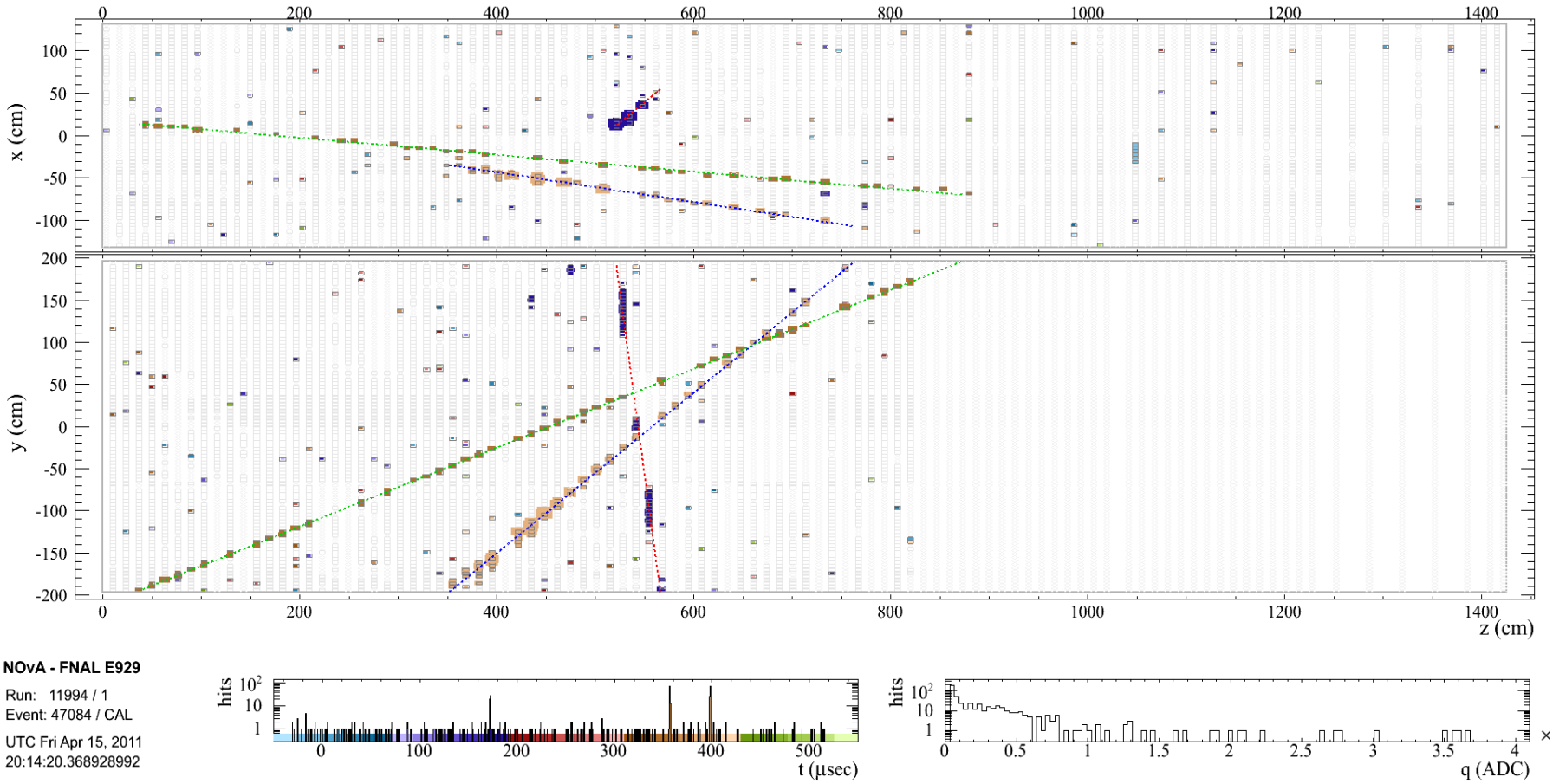


# Assembly and Operations

- Used prototype detector to test assembly techniques and detector parts:
  - Redesigned module manifolds and changed module pressure testing procedure to avoid potential cracks.
- Gained experience in qualifying and filling scintillating oil
- Tested APDs in realistic operating conditions:
  - Modified installation procedures.
  - Developed surface coating for bare APDs to protect the silicon surface from potential contact with contaminants.
  - Added an active air drying system to keep out condensation due to cooling.

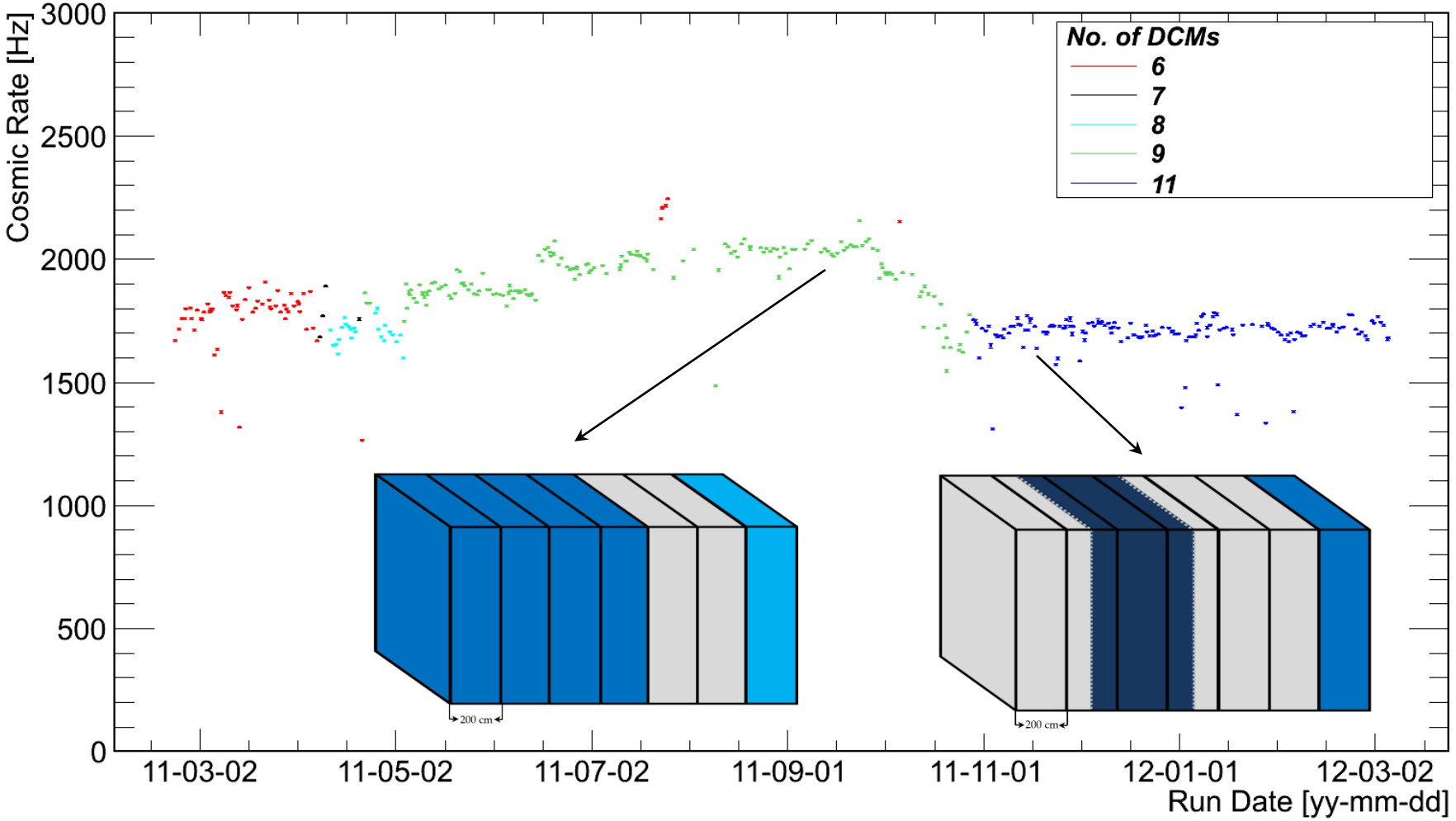



# Cosmic Ray Muon Data



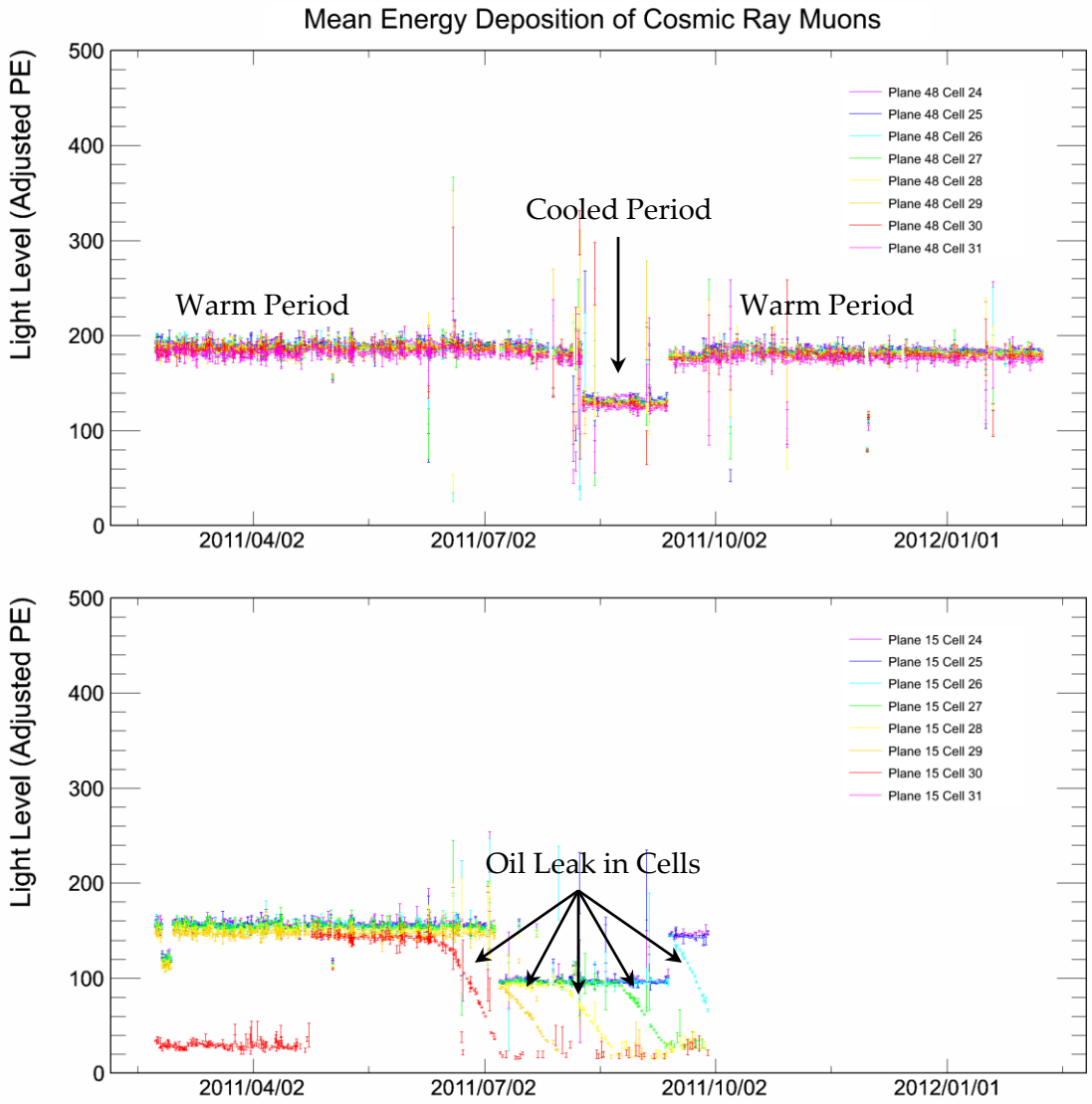

- Reconstructed cosmic ray muons are used for calibration and commissioning.
- Efficiency of cosmic tracker: >98%

# Cosmic Ray Muon Rate



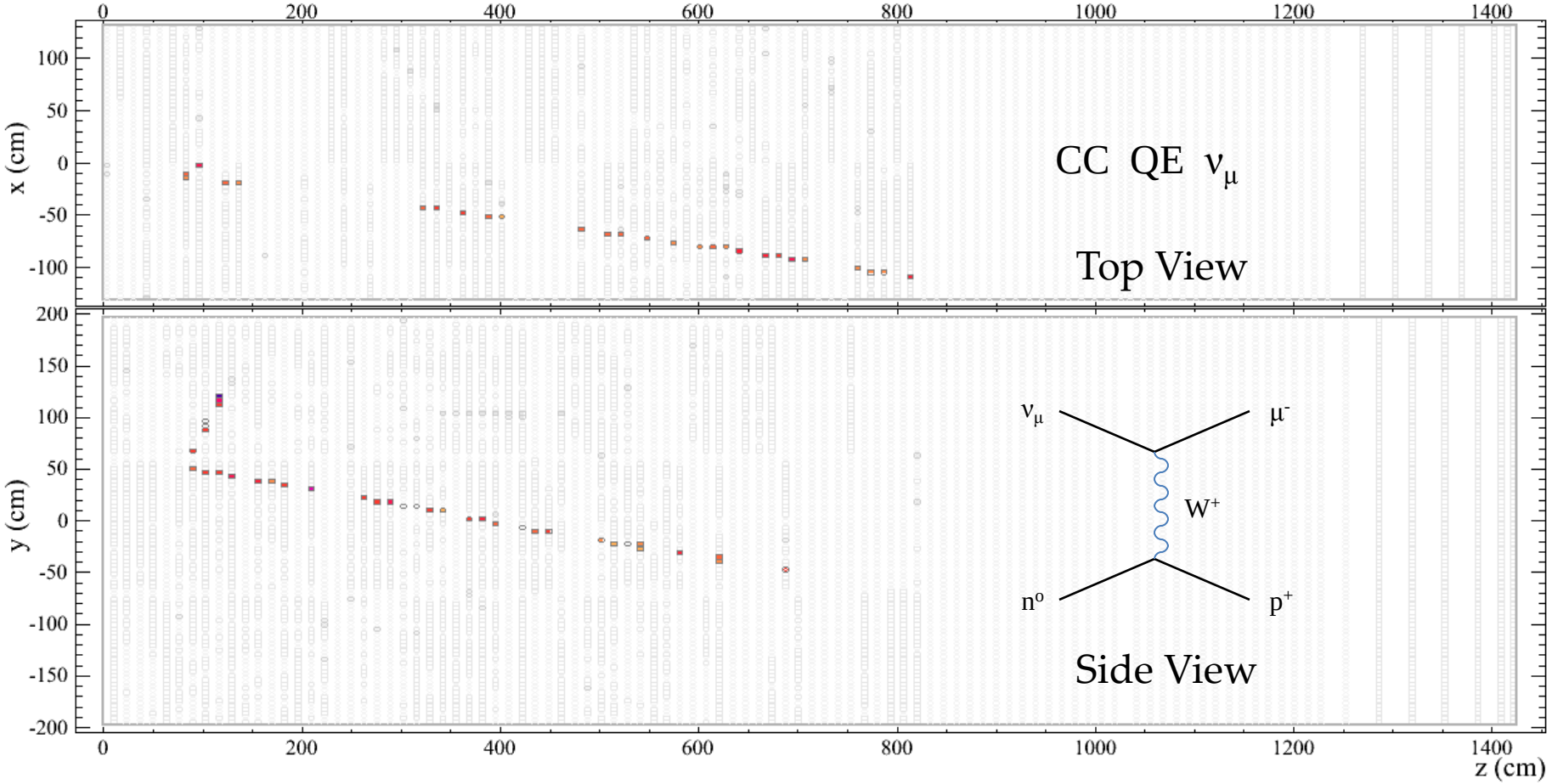

- Raw Expected Rate: 1.95 kHz = 1 $min^{-1}cm^{-2}$ (PDG – expected rate at surface of Earth) x $1.17x10^5$ $cm^2$
- Variation in early data reflects changes in the configuration of the detector. Completed configuration results in stable rate.

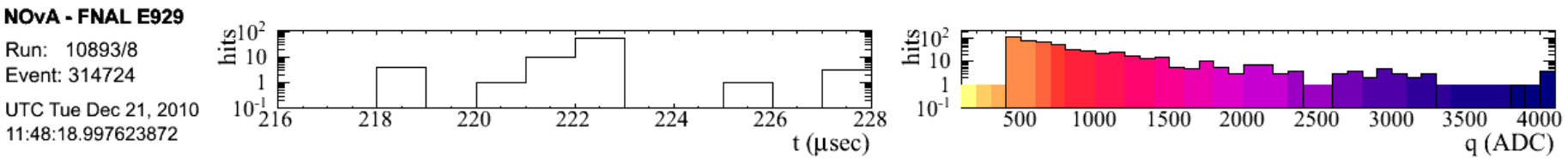
# Light Level Stability



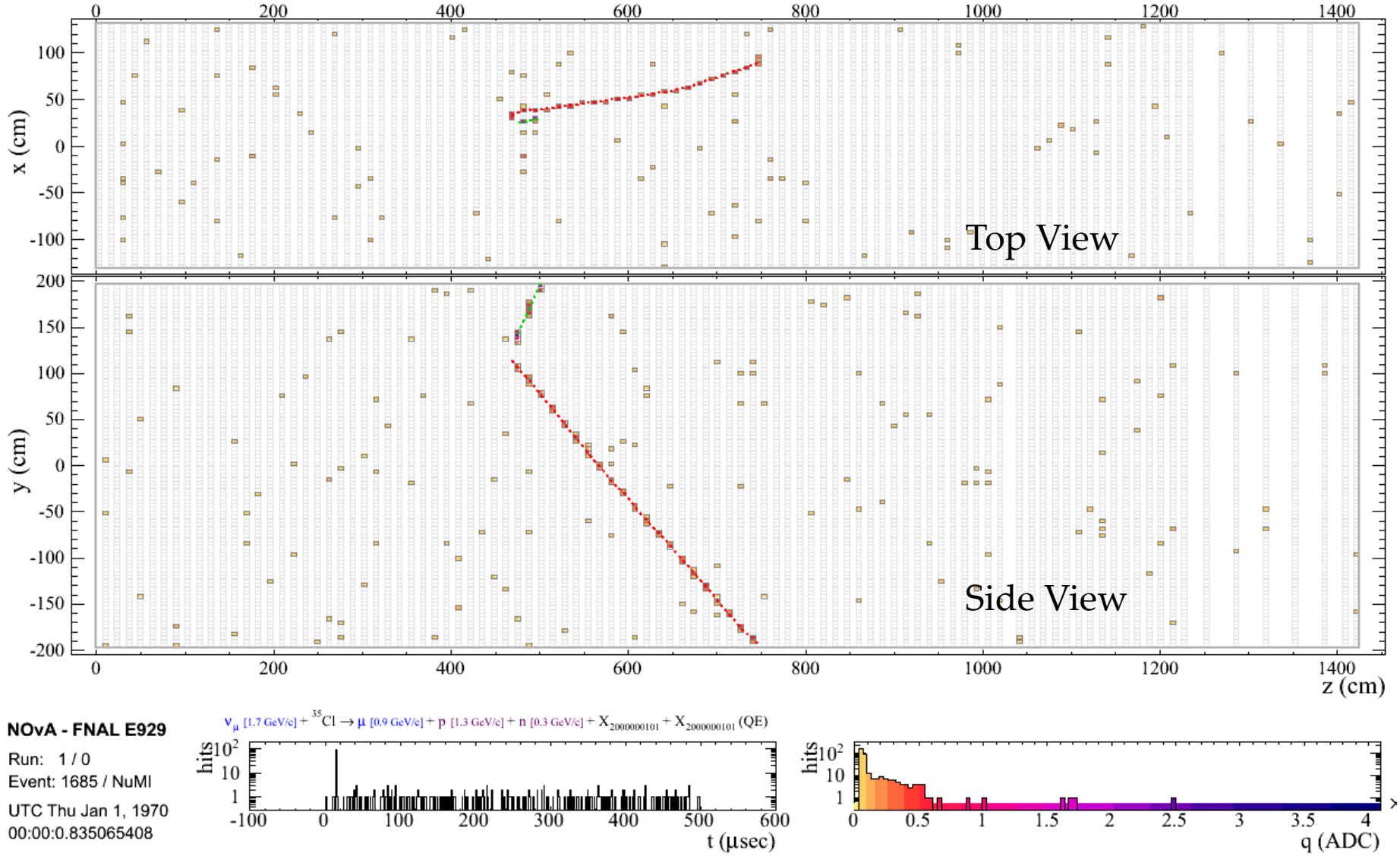

- Mean energy deposition of cosmic ray muons allow us to study the light level stability per cell.
- Light levels are uniform over time.
  - Changes on groups of cells are due to special running conditions with cooled APDs.
  - Cell by cell change shows an oil leak in a plane.
- These studies will be used in commissioning and calibration of the Near and Far Detectors.

# Neutrino Candidate – Data



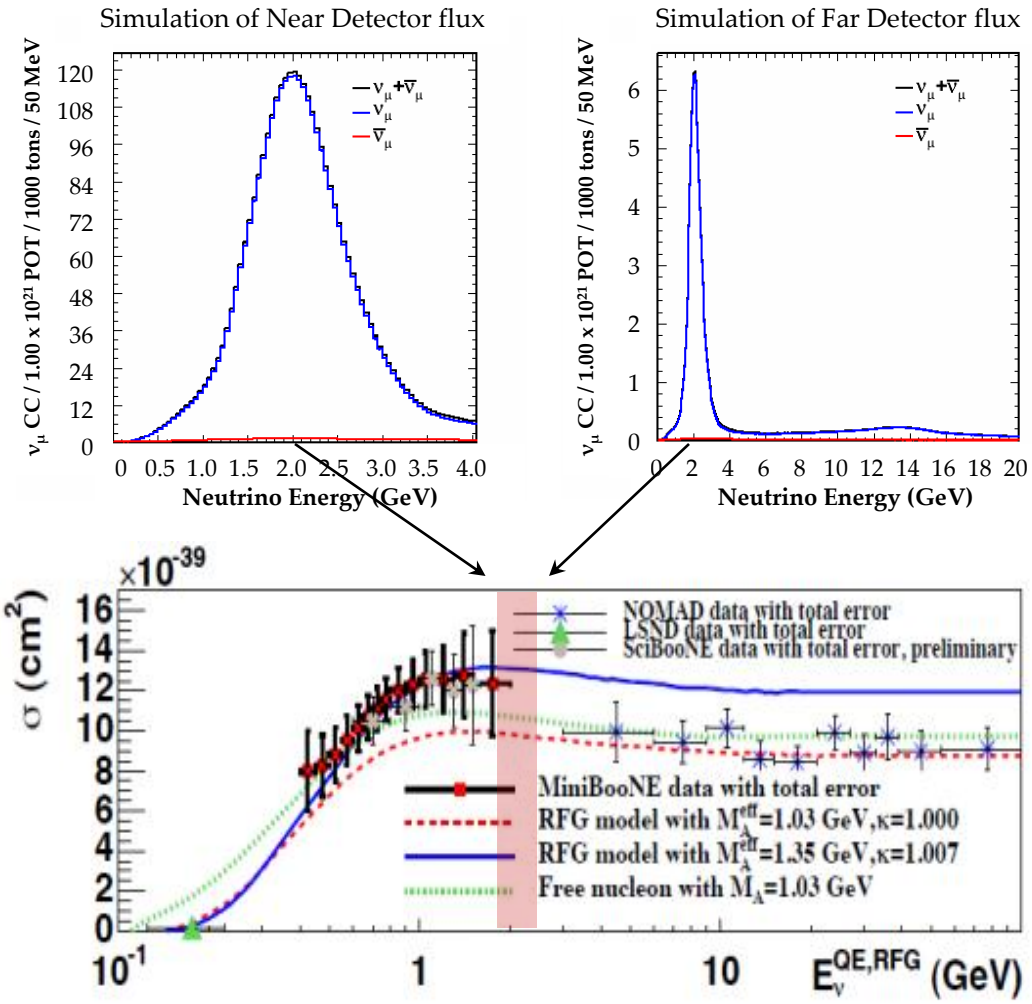



# Reconstructed Simulated $\nu_\mu$ Event

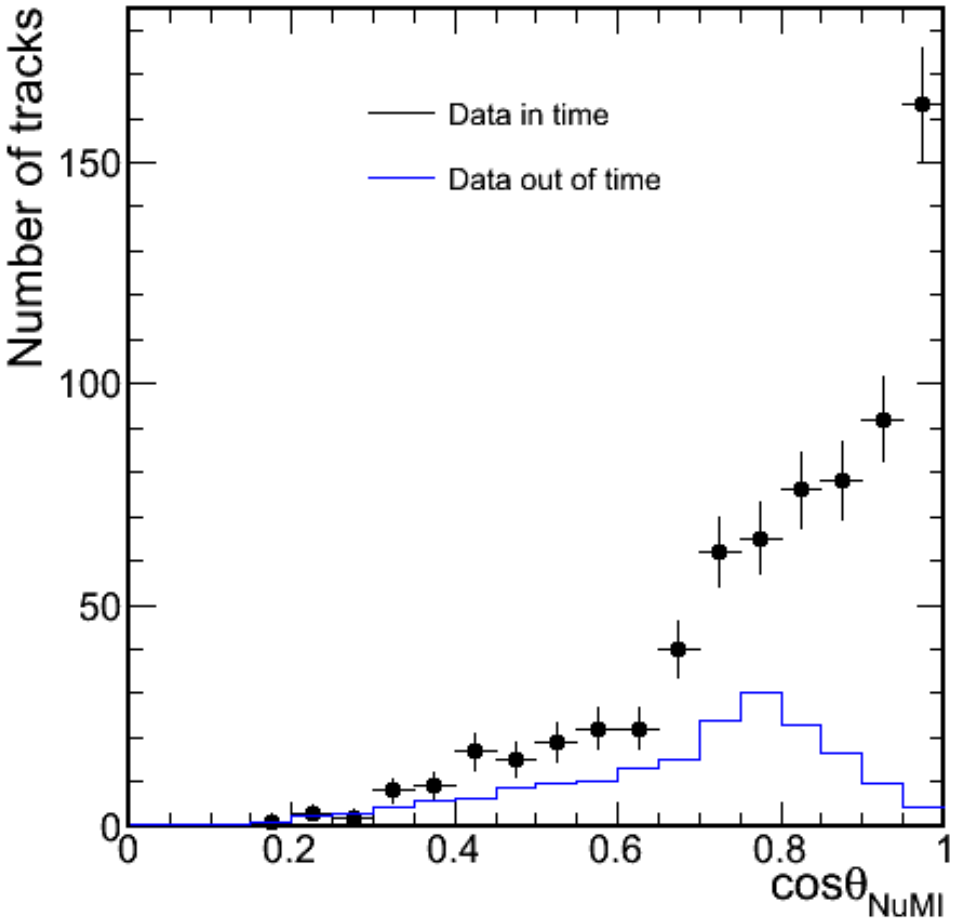


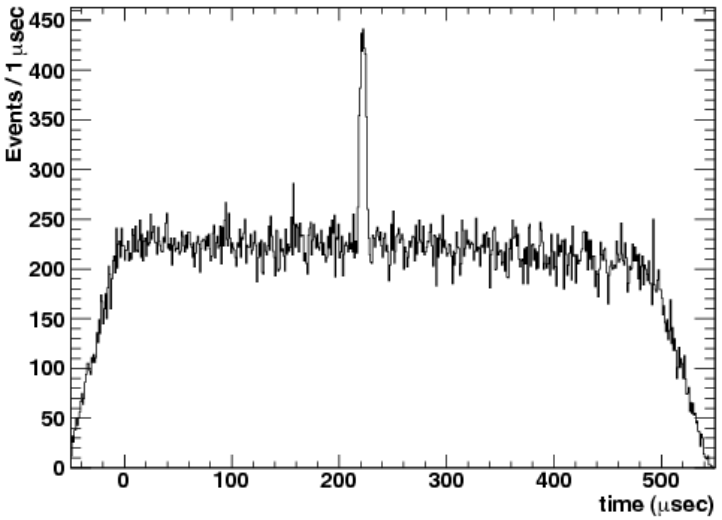
# NOvA Quasi-Elastic Studies

- The neutrino energy spectrum at the NOvA Near and Far Detectors is peaked at 2 GeV.
- The quasi-elastic cross-section at 2 GeV is not well known.
  - Measurements from other experiments disagree in this region.
- We will use the NOvA Near Detector to measure this cross-section.
  - We are using NDOS data to develop this analysis.



# Neutrino Data from the NuMI Beam

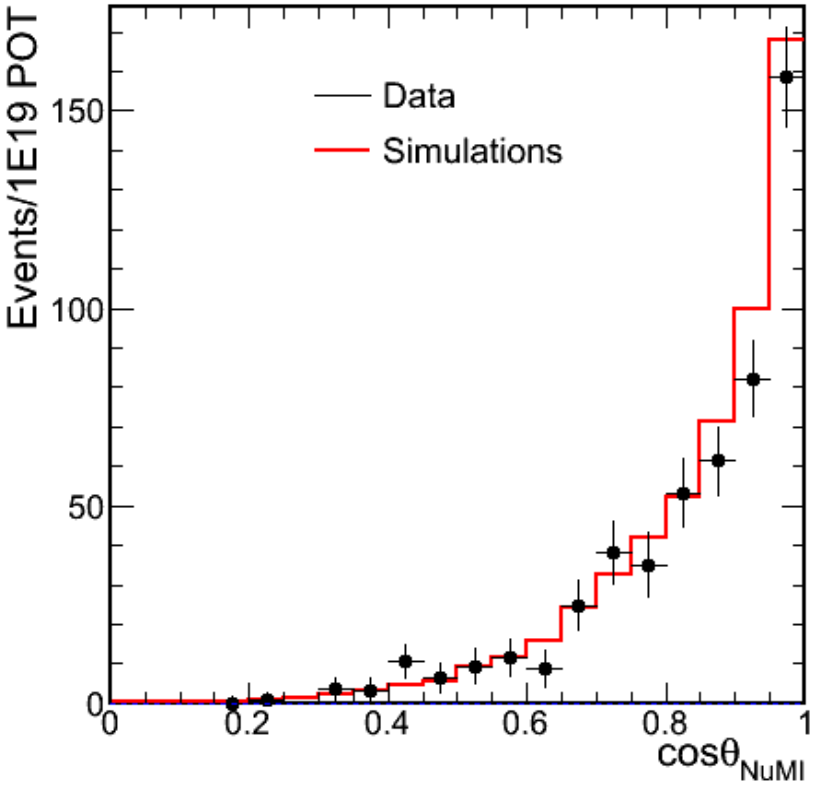


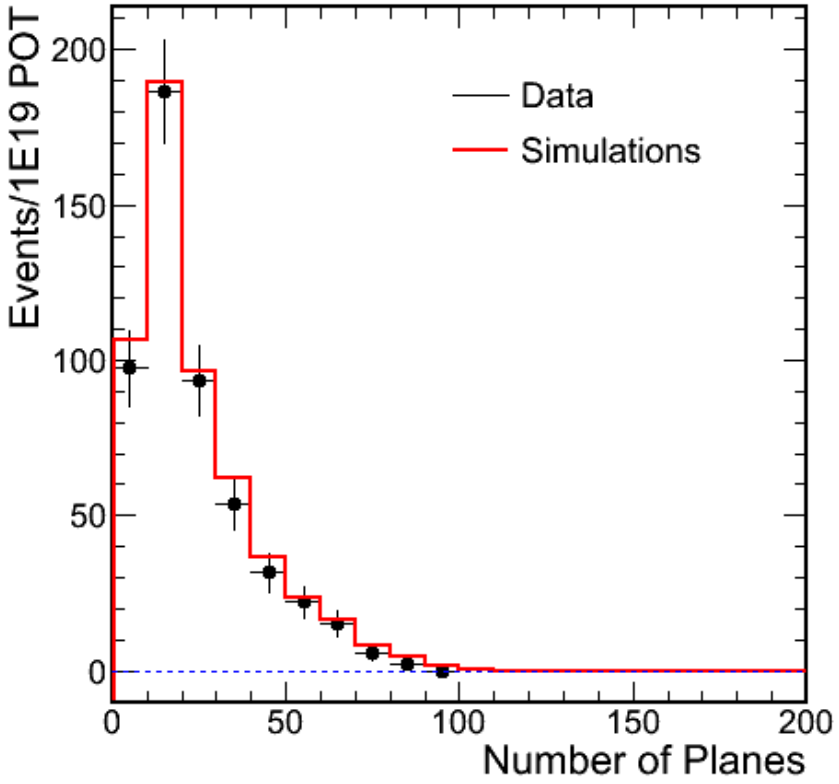




- Data trigger for the NuMI beam is 500 μsec window.
  - The neutrino spill time is 10 μsec.
  - The peak is seen at 222 μsec.
- A time window of 10 μsec is applied to define the data in time.
- The angle between the track and the NuMI beam shows a clear peak for the data in time.
- The data corresponds to $9.6 \times 10^{18}$ protons on target (POT).

# Neutrino Candidates from the NuMI Beam

- After subtracting the background from the in-time data, we obtain neutrino candidate distribution.
- Comparisons to simulated neutrinos matched well in direction and length.



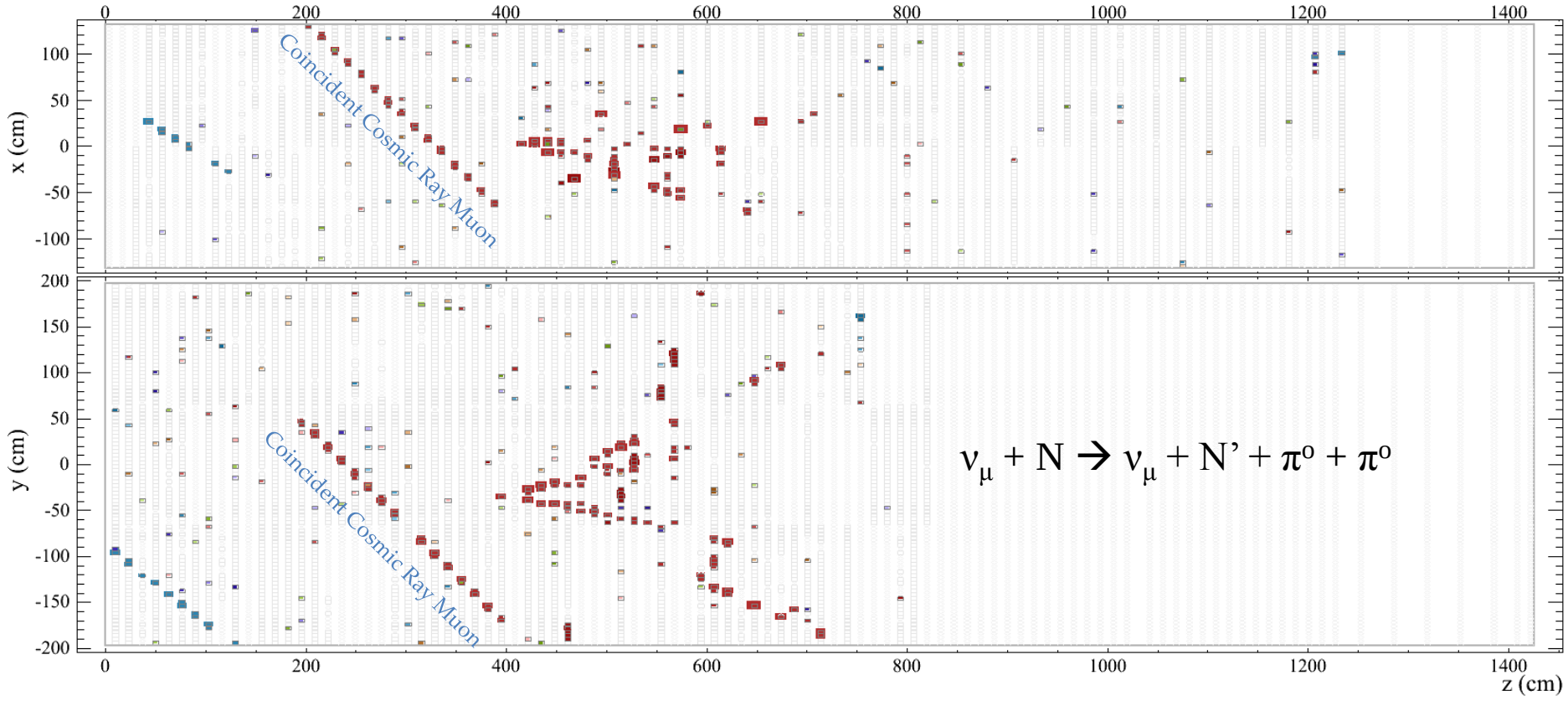



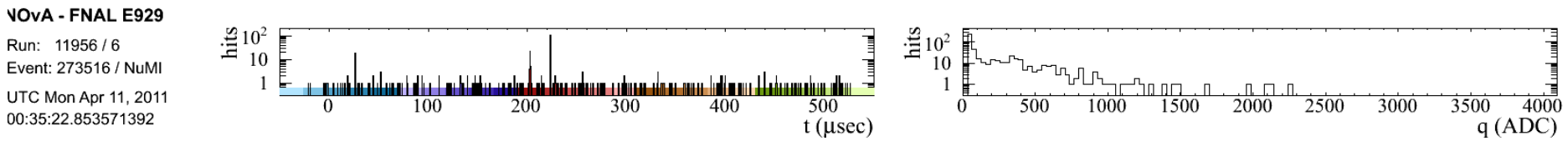
# Conclusions

- The NDOS will continue collecting neutrino data until 1 May 2012.
- We will continue testing stability of operations with cosmic ray muon data.
- We are making progress towards developing calibration and reconstruction methods, as well as physics analyses.
- NOνA will start taking data in April 2013 with 1/3 of the detector constructed.
- We look forward to exciting results!

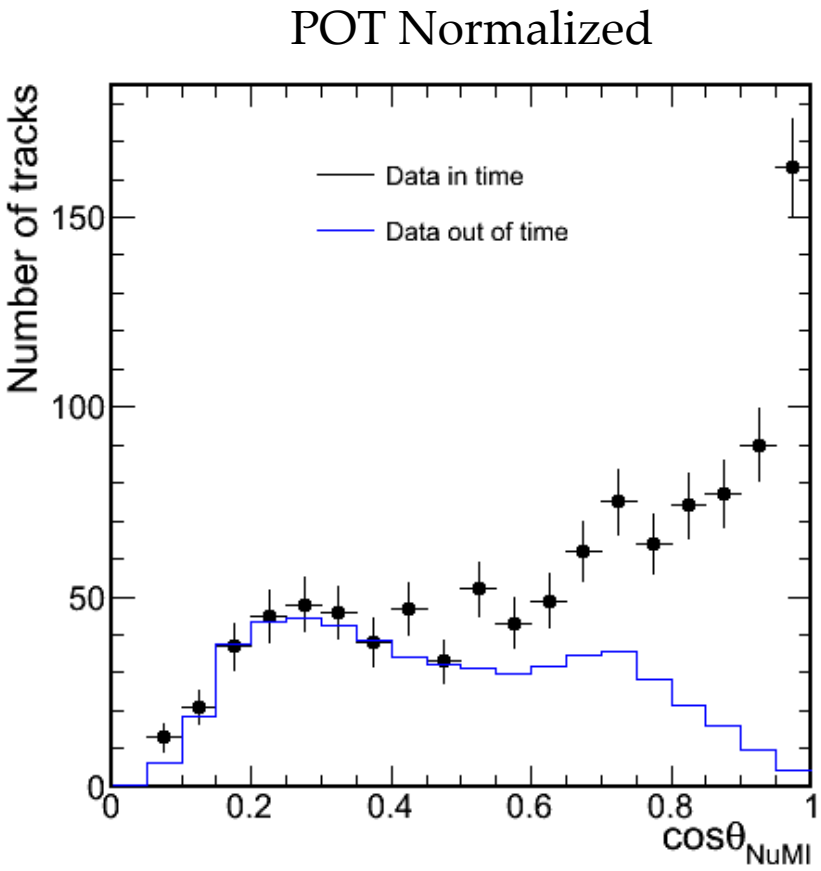
# Back-Up

# Neutrino Candidate - Data

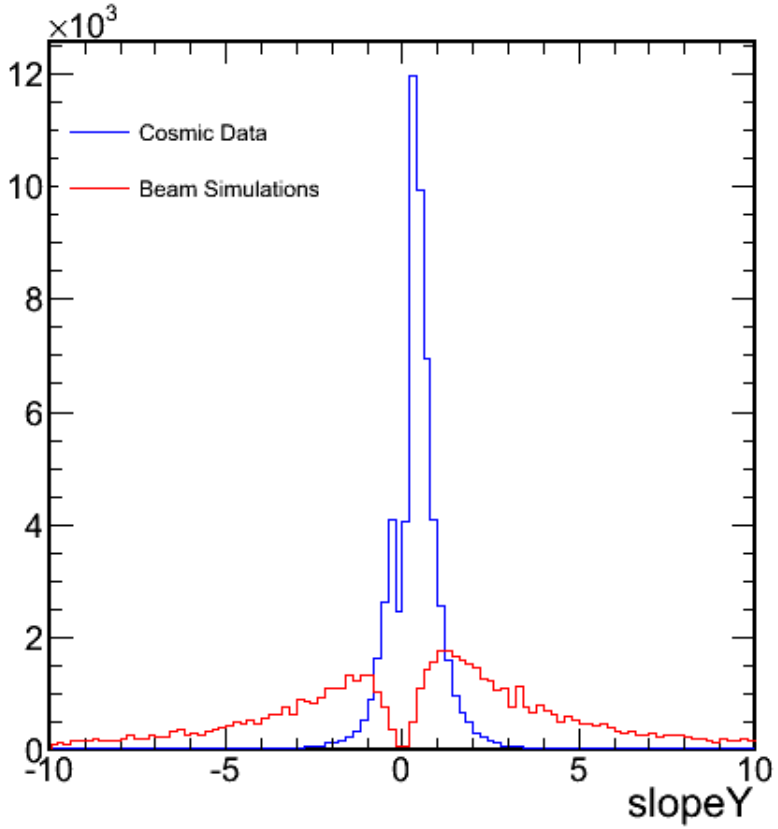


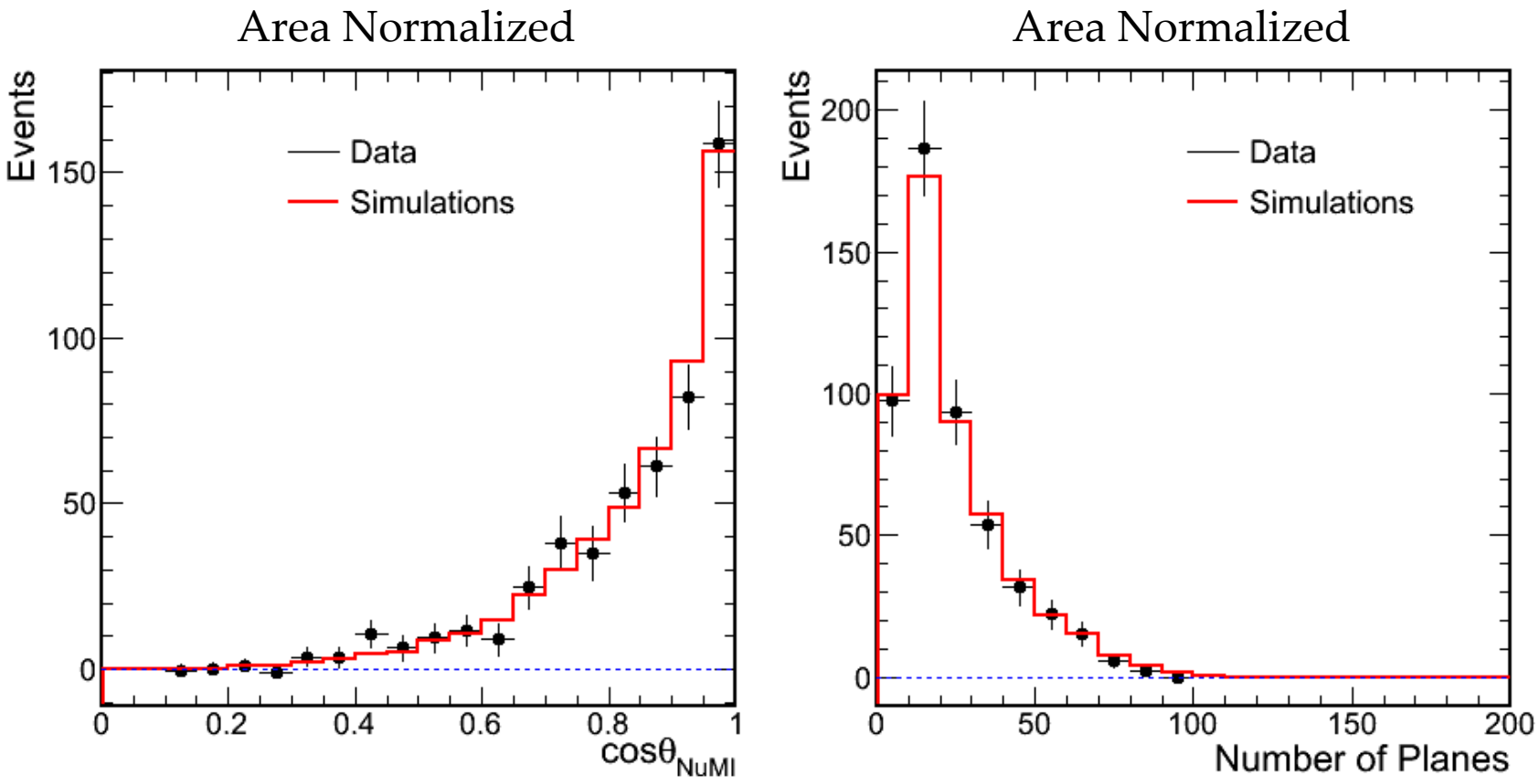
# Neutrino Candidates from the NuMI Beam



# Neutrino Candidates from the NuMI Beam - Criterion

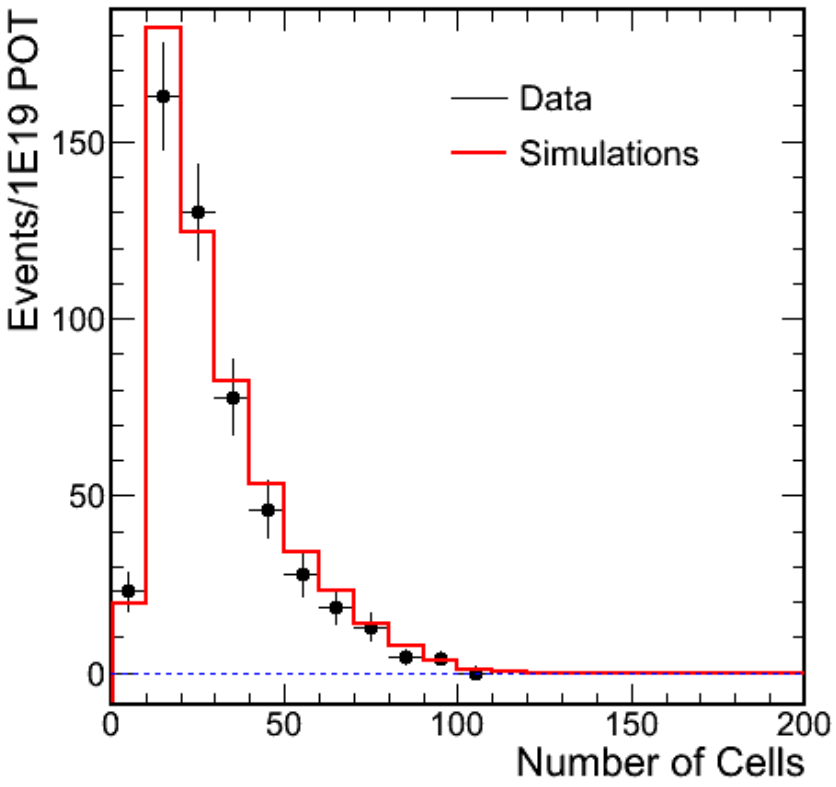


# Neutrino Candidates from the NuMI Beam

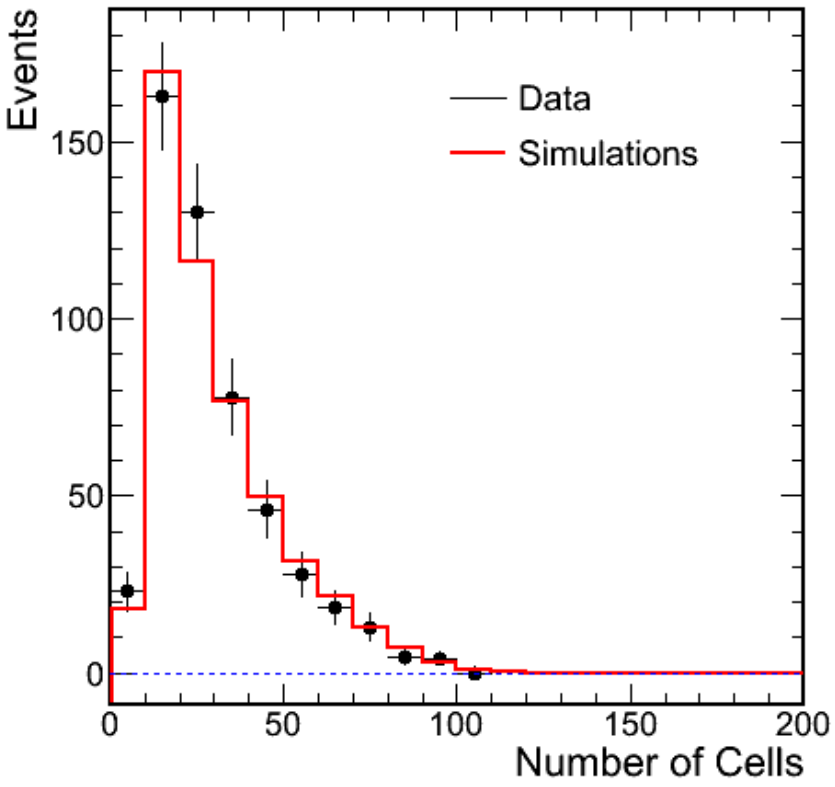


# Neutrino Candidates from the NuMI Beam

POT Normalized

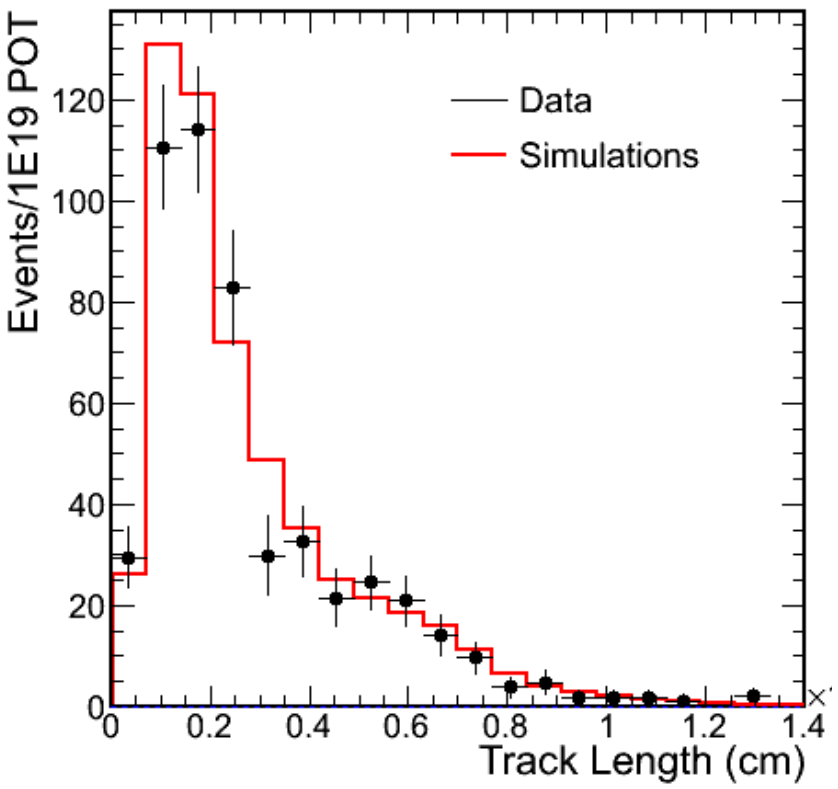



Area Normalized

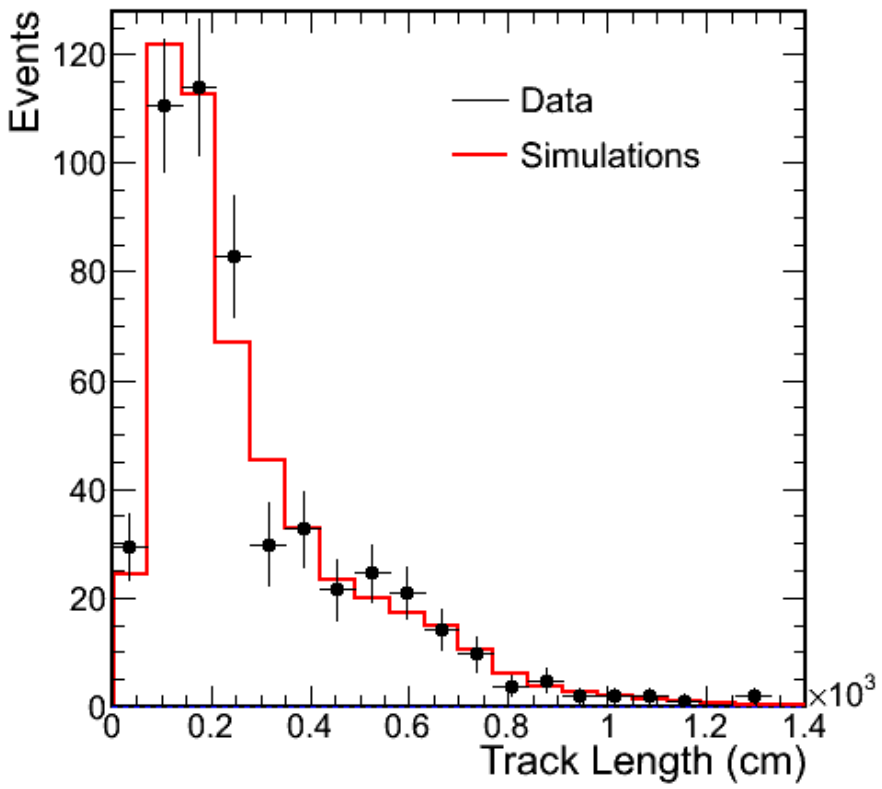


# Neutrino Candidates from the NuMI Beam

POT Normalized

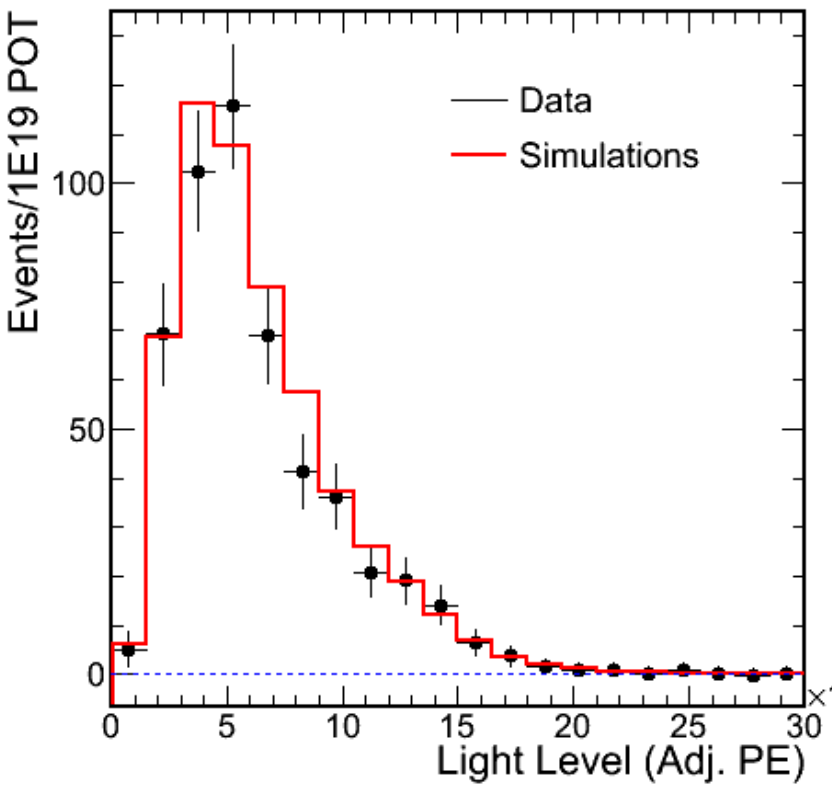



Area Normalized

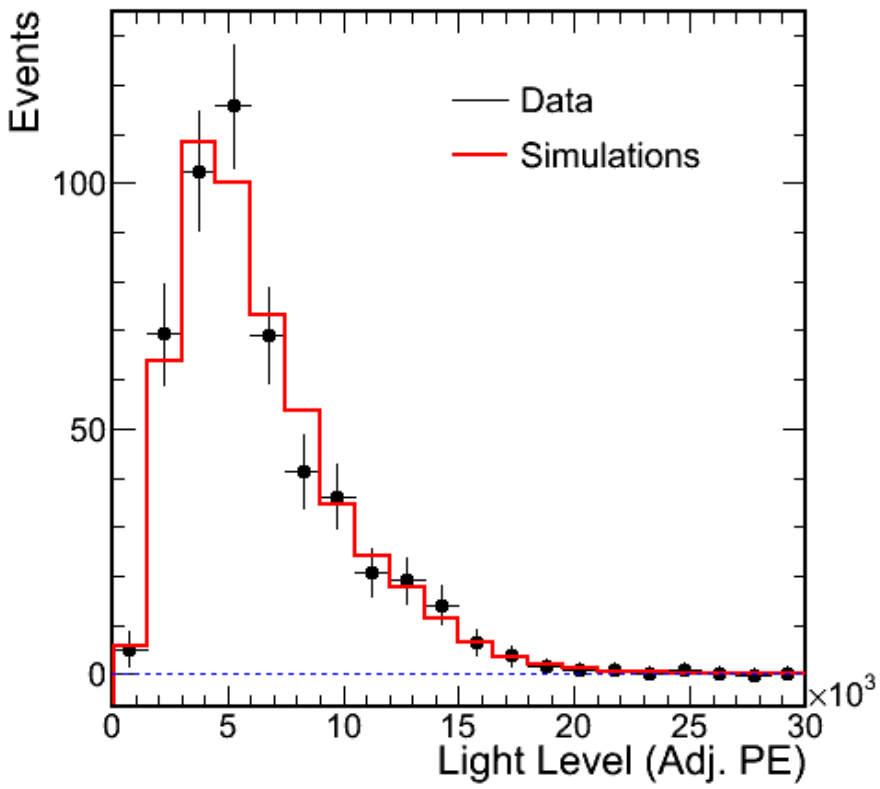


# Neutrino Candidates from the NuMI Beam

POT Normalized




Area Normalized



# Neutrino Data from the Booster Beam